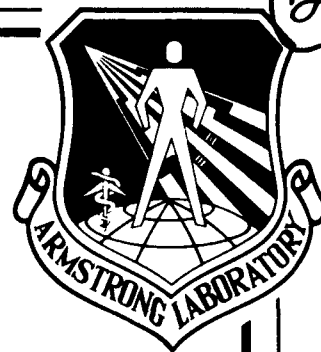


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**PACEXTRA: PACIFIC AIR FORCES
CRISIS ACTION SYSTEM EXECUTIVE
TRAINING SYSTEM**

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SEPTEMBER 1992

FINAL TECHNICAL PAPER FOR PERIOD JANUARY 1990 - DECEMBER 1990

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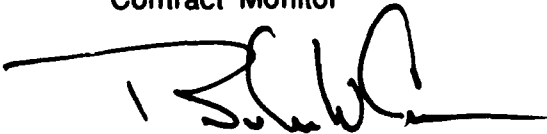
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BERTRAM W. CREAM, Chief
Logistics Research Division

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PREFACE

This report covers the design and development of a conceptual prototype for a computer-based training system to be used for command and control decision-making training research.

The project was guided by Dr. LorRaine T. Duffy and executed by the Logicon Tactical and Training Systems Division in San Diego, California, under the direction of Mr. Greg Butler. Logicon team members included Ms. Jane McGarvey and Ms. Gail Slemon. Particular thanks go to the Air Force personnel of PACAF/DOC, including Col. Robert Hammond, Lt. Col. Donald Motz, Major Keith Erickson, Major Wayne Sterzinger, and Mr. Gary Ward.

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I. SUMMARY

The decision-making skills which are key to most management jobs are generally acquired through "experience" rather than formal training. While procedures, techniques, and formulas can be explained and demonstrated to a management trainee, it is unlikely that he or she will be able to reliably and effectively apply them on the job without practical experience. Training systems attempt to provide that experience prior to the job in a realistically controlled, efficient, and economical environment.

This management training problem is prevalent in the command and control community. This project addresses that problem with an experimental training system intended to provide "experience" to those officers at Headquarters (HQ) Pacific Air Forces (PACAF) who are preparing to perform the job of Executive Officer in the Crisis Action System (CAS). The targeted personnel are typically majors or lieutenant colonels with operational experience. Their job will be to filter all incoming messages at the command and control center, determine the significance of each, and assign and track responding actions within the CAS staff. This includes drafting new messages and/or coordinating communications in person or by phone with a wide variety of people and agencies, both within and outside of the command center. Because the tasks are necessarily "intellectual" and not "manual," it is difficult to train without reference to the milieu in which the tasks are conducted.

A common method of providing training for this CAS Executive job (as well as other jobs in CAS) is to conduct exercises which simulate in vivo involvement in and response to crises. While these live exercises may be the most effective method of training, they are infrequent, expensive, and can only serve a limited number of trainees.

The product of this project, PACEXTRA (PACAF CAS EXec TRaining) is an experimental system designed to provide individual CAS Executive trainees with private exercises on intellectual and coordinative tasks, conducted interactively on a microcomputer. It presents them with incoming messages, phone calls, and visits from CAS staff members, and permits them to respond with messages, phone calls, and tasking of staff members. The system also provides trainees with reference materials and forms on which to log events and track suspenses. Trainees are provided varied levels of assistance and prompts, including advice and feedback on actions to be taken as a result of specific exercise events.

One of the more significant features of PACEXTRA is a built-in authoring system which makes it possible for any CAS Exec Subject Matter Expert (SME), responsible for training other CAS Exec trainers, to create and revise training exercises as needed. This is done through a graphic, user-friendly, interactive, on-screen process which requires no special skills and no programming background.

Although PACEXTRA trains only PACAF CAS Exec officers, it exemplifies a means of economically and efficiently providing exercise-based individualized training for almost any event-driven job. This instructional approach and medium could serve any technical training program from store clerk (whose tasks tend to be manual and procedural) to space vehicle crew member (whose tasks are more intellectual, coordinative, and unmeasurable).

II. PROBLEM

The process of making good decisions, on any job, is a complex mixture of setting goals, collecting information, defining alternatives, weighing options, and choosing solutions. While rules, guidelines, and procedures can be established to aid in this process for a particular job, and training for the job can explain and even demonstrate proper application of these, trainees seldom reach uniform proficiency in decision-making. Decision-making proficiency is a function of knowledge, skills, and rules acquired through varying operational experiences. In this case, an attempt was made to focus on the knowledge and decision-making acquired through in vivo experimental training, as opposed to rule- or skill-based decision-making.

The PACAF CAS is formed only during times of crisis or exercise. The job of the CAS Executive Officer is to assist the CAS Director in managing the CAS and its staff of up to 40 or 50 people. The primary CAS Exec duties are to screen all incoming correspondence (a majority of which are messages) to determine what action, if any, is required of the CAS; assign that action to one or more staff members; and track the progress of that action to its completion. Secondary duties include compiling reports and briefings for Headquarters or other agencies.

The job of PACAF CAS Exec is filled by officers assigned to the Directorate of Command and Control (DOC) under the Deputy Chief of Staff for Operations (DO). Several people must be available for multiple 12-hour CAS shifts. These shifts are combined with other normal duty commitments, and are subject to typical reassignment rotations. This creates the need for ongoing training of new CAS Execs and, in turn, demands on-the-job experience which previously would only be gained during actual crises or large-scale exercises.

III. APPROACH

Overview

The approach taken to experimentally address the problem of providing CAS Exec trainees with realistic job-like experience has been to employ state-of-the-art off-the-shelf microcomputer software and hardware to develop individualized job-like exercises. Apple Macintosh computers were chosen as the training environment due to their availability in the command center. The exercises place CAS Exec trainees in a full-color graphic environment which replicates the PACAF CAS. A scenario of realistic crisis-related events is presented (see Figure 1). The trainee is expected to judge the significance of each event, determine if CAS Exec action is appropriate, and, if so, take action using on-screen tools. These tools replicate real-life means of decision execution. They include the means for making phone calls, sending messages, tasking staff members, taking notes, logging events, tracking suspenses, using references, and compiling situation reports (SITREPs) (see Figure 2). The trainee can also obtain advice and feedback on the appropriate

actions for each event (see Figure 3). This is available at various expertise levels, depending on trainee experience and training need.

The training system, PACAF CAS Exec Training (PACEXTRA), also incorporates an interactive authoring system which allows SMEs to create and refine training exercises. This system facilitates the creation of individualized exercises, composed of a chain of custom events, through a graphic interface which requires no programming and minimum training.

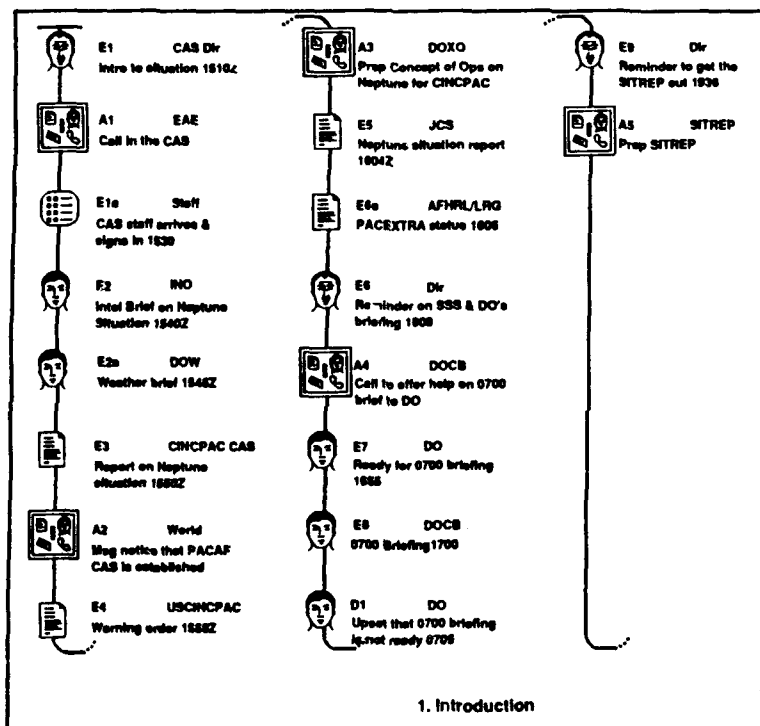


Figure 1. PACEXTRA Scenario Overview

Figure 1. PACEXTRA puts CAS Exec trainees in a graphic environment representative of the actual PACAF CAS. (Note: The quality and content of the actual screen display were degraded significantly in de-colorizing it for this printing.)

PACEXTRA

- **PROBLEM:**
 - Crisis Action Centers are fully manned only during actual crises
- **NEED:**
 - Training vehicle which provides realistic practice without presence of full staff
- **SOLUTION:**
 - Highly realistic, SuperCard-based, exercise shell
 - User friendly exercise authoring system for use by SMEs
- **IMPLEMENTATION**
 - Software: SuperCard, Super 3-D
 - Hardware: Macintosh
 - Example: Crisis Action Center at HQ PACAF
- **NOTES:**
 - System is a prototype
 - Research vehicle for Air Force Human Resources Laboratory
 - Technical Report scheduled for December 1990

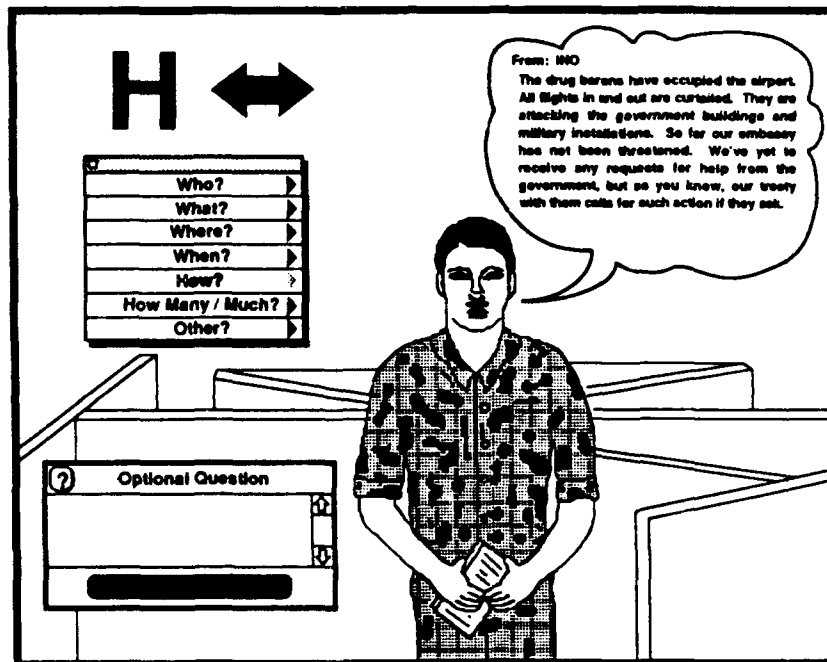


Figure 2. PACEXTRA Introduction Screen

Figure 2. Trainees interact with simulated CAS staff members through graphic screens which incorporate two-way textual conversations. (Note: The quality and content of the actual screen display were degraded significantly in de-colorizing it for this printing.)

Anticipated Action #		A3		Intro and message response tasking	
In response to the event # E3. It is anticipated that the CAS Exec would				Request for response message from staff <input type="checkbox"/> publish the SITREP, and this <u>has</u> been done	
OR <input type="checkbox"/> make a phone call... or <input type="checkbox"/> send a message... or <input type="checkbox"/> make verbal contact... write to					
or	LQ Exec	and		and	
		and		and	
		and		and	
If a message is sent it should also INFO:					
		and		and	
The Exec's correspondence remarks should include the following key words/topics:					
or	message	and	13 13AF LQX	and	
		and		and	
		and		and	
Exercise monitoring indicates that this anticipated action <u>has</u> been taken <u>not yet</u> been taken.					
<input type="checkbox"/> A suspense item should also be created, and this <u>has</u> been done					
<input type="checkbox"/> A log book entry should also be made, and this <u>has</u> been done.					
Presented above is the action expected of the trainee in response to the preceding event. If you have not yet taken this action, you may still do so. Future events may be influenced by the completion/incompletion of this action.					
Continue					

Figure 3. PACEXTRA Feedback Screen

Figure 3. A trainees review advice and feedback through a display listing the type, recipients, and content of their anticipated communication.

Planning

Planning for PACEXTRA involved three major steps:

1. Confirming the CAS Executive Officer's job as the best subject matter for the experimental training system,
2. Determining the instructional method to be used, and
3. Selecting the appropriate hardware and software.

Subject Matter Confirmation

This project is the second in a two-phase program to experimentally enhance CAS decision-making training at HQ PACAF. The first phase was the PACAF Command Control Information and Training System (PACCITS). PACCITS addresses the training and information retrieval needs of the entire PACAF CAS by providing a random access information retrieval

system. This black and white system employs the Hypercard software which is provided on all Macintosh computers in the CAS.

During the development of PACCITS, the Air Force Human Resource Laboratory, Ground Operations Branch staff, PACAF/DOC staff, and Logicon representatives considered a means of applying more advanced forms of hypermedia to focus training on a specific CAS position which is heavily decision-event driven. Primary factors considered were the criticality, complexity, formal definition, and turnover of various CAS staff positions. It was decided that the CAS Exec position was the best candidate because: 1) it manages the rest of the staff, 2) it often is involved in all CAS activities, 3) it follows published procedures, 4) it is mainly dependent upon the decision-making skills of the officer, and 5) it is always fully manned (by a large pool of qualified personnel) whenever the CAS is active.

Instructional Method Determination

The CAS Exec's job is primarily one of reviewing each piece of incoming information (mainly in the form of messages) and determining what, if anything, should be done; who should do it; and how long it should take. The Exec then coordinates this with the CAS Director and tracks progress.

While the process itself is simple, acquiring the judgmental skills required to make the proper decisions typically takes "experience" and is a training challenge. Therefore, a training mechanism was created which could provide pseudoexperience through a simulation of the job and its environment, including typical crisis action events. It is formatted much like a business "in basket" exercise; however, it can give advice on handling each event, provide varied means to complete an action, and generate feedback on that action. In other words, the system offers guided experience with feedback which a typical "in basket" exercise is not capable of providing.

Selection of Hardware and Software

Macintosh was the only hardware considered for the project because of its prevalence in the PACAF Command Center and its proven instructional capability. SuperCard was chosen as the primary software for PACEXTRA because it was efficient to use (both in developing graphics and other objects and in programming), inexpensive, and compatible with the Macintosh hardware already on hand in the PACAF CAS.

Design

The design process for PACEXTRA was three-phased, consistent with the three major components of the system. First, the exercise system was designed, then the authoring system, and finally the lessons. All design was constrained by the chosen hardware and software.

Design of the Exercise System

The goal of the Exercise System was to replicate, as realistically as possible, the environment in which the CAS Exec performed his/her job in order to provide "real" experience in the events he/she would encounter. The desk and related locations and items in the CAS "Ballroom" were provided graphically. This "ballroom" contains seven desk groupings, five of which are hexagonal cluster units. The other two are a set of four administrative area desks, and a modified U-shaped desk set at which the directors and executive officers sit. All desk groupings are represented on the PACEXTRA screen.

"Super 3D" software was used to create a three-dimensional, electronic, colored model of the complete ballroom complex, including furniture and pertinent equipment, with varied level of detail. Electronic "snapshots" of any point in the room could then be taken from any eye point and at any range. Realistic perspective views from the Exec's desk (including phone, books, in-basket, terminal, etc.), as well as any location in the room that is pertinent to a decision being made, were thus provided.

To present and control these views and the variety of event-related items, the windows, fields, buttons, and graphic objects inherent to SuperCard were used. Thus, exercise characters, their words in cartoon-like bubbles, messages, phone conversations, book pages, etc. would all be developed as overlaying objects, with the scene itself in the SuperCard "background." This approach would be efficient to implement and would facilitate modifications as the system matured and was tested. The standard 640 X 480 pixel Macintosh screen was chosen so the exercises could be run on any Macintosh II hardware with sufficient memory and speed. On-line aids were provided to introduce trainees to PACEXTRA.

Design of the Authoring System

The goal of the PACEXTRA authoring system is to allow those personnel supervising the training for the CAS Exec job to create and modify exercises with only an hour or two of training on the use of PACEXTRA. Since the heart of an exercise is the events and subsequent trainee actions, the authoring process centers on a graphic "chain of events." The chain is on multiple screen "pages" and is created by linking graphic icons representing different event types and anticipated actions, each one labeled with its identifier, name, and source. "Double clicking" individual icons on the chain will take the author to the same screen the trainee will eventually see when that event occurs. The author can then add all the details. The author works with a graphic chain of events representing the sequencing of the exercise and providing access to the details of each event or anticipated action. In addition, it is possible to define questions the trainee may ask of event characters and the possible responses the system will give.

To provide a realistic set of people within the CAS with whom the Exec interacts, a supporting "cast of characters" authoring

process was created. The author combines faces and bodies (in Battle Dress Uniforms (BDUs) or flight suits) and assigns each to an agency and desk in the ballroom. Thus, a broad cross section of rank, race, and sex can be used to staff the CAS with a different group of people for each exercise. This approach permits an author to change or move agencies, thereby remaining current with the real CAS as it changes. This also provides a more interesting milieu for the student performing the CAS Exec duties. An on-line authoring aid was designed so exercise authors could learn about the authoring process while on the system. This, and the guide for trainees, is available in print separate from this report.

Design of the Exercises

Design of the first of two exercises involved meetings with PACAF DOC and DOX staff members. In these meetings, it was decided that the subject of the first exercise would be an insurrection in a fictitious island-country called Neptune. The events and actions would involve establishing a Joint Task Force (JTF) and supporting the JTF with fighters, tankers, troops, supplies, equipment, and airlift. The second exercise focuses on orienting the new Exec to the CAS through events involving the staff. This tests the application of this system to a slightly different form of training than the crisis action experience itself. (In practice, the trainee ideally goes through the orientation exercise first, followed by the Neptune exercise.)

The exercise design process begins with the development of a "short story" on paper. (It is important to note here that this first step is not a storyboard, but rather just a skeletal narrative of the events and actions planned. A storyboard is inappropriate because the subsequent authoring process will create displays which automatically consist of chosen ballroom scenes, people, and text. To presketch them would be wasteful and counterproductive. It could be said that the on-system authoring process automatically creates a storyboard as the first draft of the exercise.) Once the story is developed, the cast of characters is created on the system and events are sequenced on the on-screen chain. Finally, the details which reflect the "short story" are added. Thus, the exercise design and development process become one when the story is drafted.

Development

The PACEXTRA development process consisted of five major steps:

1. Collecting subject matter details;
2. Producing the required graphics;
3. Developing the supporting software;
4. Authoring the exercises; and
5. Testing, refining, and reporting the system.

Each step is addressed in the following paragraphs.

Collecting Subject Matter Details

Information on the CAS Exec's job, the tools he/she employs, and the environment in which he/she works was obtained through visits to PACAF/DOC. Unclassified documents and forms were collected; measurements and photos of the ballroom were taken; and discussions were conducted with staff members, particularly those already qualified for CAS Exec duty. As the system matured it underwent an informal formative evaluation by these people.

Producing the Required Graphics

Photos and measurements of the ballroom and its equipment were used to electronically model the principal CAS physical components to scale using Super 3D software. This included the desks, chairs, printers, and large screen displays throughout most of the room in a moderate level of detail. At the Exec's desk, detail was taken to a more refined level, including the individual phone buttons and the binder rings on clipboards and notebooks. Then electronic "snapshots" were taken of Super 3D ballroom screens, set up to represent the Exec's line of sight while seated at the desk, while turned to talk to the Director, while turned to talk to visitors, while approaching each desk cluster, and while approaching an individual cluster desk position. Capture software was used to import the electronic snapshots into the SuperCard environment as card backgrounds.

Super 3D was also used to create enlarged views of the Exec's tools, such as the telephone receiver, opened and closed notebooks, message clipboards, computer terminal, etc. These were captured and imported into SuperCard as graphic objects. The graphic functions built into SuperCard were used to modify and embellish these items and create other items such as the cartoon-like bubbles which enclose the words spoken by scenario characters.

To support the process of creating a cast of characters, a graphic artist drew monochrome faces and bodies using SuperPaint. These were imported to SuperCard where they were sized, colored, and refined to create a library of 24 faces and 12 bodies. These include male, female, black, white, officer (Major), enlisted (MSgt.), BDU, and flight suit. The author must access these on pallets while using the "Casting of Characters" feature.

The drawing and painting features of SuperCard (in some cases aided by Super 3D) were used to create the remaining graphics. These include the icons and background for the event chain; large "Help," "Stop," and "Next/Past Event" buttons for the trainee; and other items on behind-the-scenes authoring screens. SuperCard's buttons and fields were used extensively in this area.

Developing the Supporting Software

As explained previously, a great deal of the PACEXTRA development involved using the nonprogramming features of Supercard to create windows and cards, draw and paint graphics, and define and insert buttons and fields. However, these hypermedia functions alone are only a portion of PACEXTRA. To make the system perform as it does, a significant amount of software code (Supercard script) was written. Approximately 1000 hours of programmer's time was required for this.

Due to the object-oriented nature of SuperCard, the unique PACEXTRA code (script) is contained in the various system objects including projects, windows, backgrounds, cards, fields, buttons, and graphic objects. The PACEXTRA Software Document (separate from this report) describes the software scheme in some detail. The script itself is accessible within PACEXTRA through SuperCard and its subsystem, SuperEdit.

Authoring the Exercises

The two exercises were developed by first outlining a series of events on paper (similar to outlining a short story). A cast of characters was then developed to staff the CAS. A chain of events and anticipated actions (responses by trainees) was developed on the system, and details were added to each event and action. These details included the text of messages, phone calls, and direct contact with CAS characters. They also included the definition of any conditions (trainee actions) which are to influence the occurrence of specific events. The result of this process, and the reviews and refinements which followed, are the two exercises delivered with PACEXTRA.

Testing, Refining, and Reporting the System

The scope of this project did not allow for formal testing of PACEXTRA. Testing has been limited to that done by Logicon during development, and as a result of using the authoring system to develop the two delivered exercises. Informal formative evaluations were conducted with the PACAF/DOC staff.

IV. RESULTS

This project resulted in the production of an experimental prototype of a microcomputer-based training system called PACEXTRA. It runs on a Macintosh II computer and provides individualized exercise-based training to those preparing to perform the duties of Executive Officer in the PACAF CAS. The system demonstrates the concept of using low-cost, hypermedia software (SuperCard) to create a user-friendly exercise authoring tool, the implementation of which results in realistic event-driven exercises. These exercises put the trainee into a highly graphic on-screen environment, which is expected to provide high transfer of training to the real job environment. The exercises challenge the trainee with events; the trainee must decide what action

should be taken. The system provides four levels of advice and the means of taking action in realistic job-like ways such as sending messages or contacting others, either directly or by phone. Feedback on what was expected and whether it was accomplished are provided for each event.

This project focused only on the design and development of the training system and included no evaluation or research on its effectiveness. Any such future research by AFHRL or others will be reported separately.

V. DISCUSSION AND CONCLUSIONS

Lessons Learned

Informal review of PACEXTRA by the PACAF/DOC personnel has been positive. Indications are that its realistic modeling of the CAS Ballroom and the events which occur therein will provide effective training with a high degree of transfer; however, this has yet to be proven.

Use of the authoring system by the Logicon staff has shown it to be easy to use and capable of creating a comprehensive set of realistic events and anticipated actions. The capability to easily add, move, modify, and delete individual events, independent of other events, is significant. It makes progressive exercise development and revision at any stage of development very practical and efficient. An author can first create a skeletal exercise (with minimum events), run that exercise in the trainee mode, then add to it as the trial run dictates. Preliminary versions of exercises can thus be created in a few hours.

SuperCard has proven to be a very capable software utility, particularly in light of its price (under \$300). However, a limitation is the time it takes to change from one display screen to another when the exercise is running. This is particularly true if the display includes multicolored compound graphics (as many PACEXTRA screens do). PACEXTRA was tested on the "basic," "ci," "cx," and "fx" versions of the Macintosh II microcomputer; the system only runs at a reasonable speed (average two-second screen change) on the top-of-the-line "fx" model. In addition, due to the multiwindow approach used on PACEXTRA, the hardware must include a full eight megabytes of memory. Otherwise, the system will freeze up when enough windows are open to saturate the memory.

Lessons regarding the true operational utility and training effectiveness of PACEXTRA must await its application in the field and any related research.

Advantages and Disadvantages of Approach

The advantage of employing a low-cost, off-the-shelf, object-oriented, hypermedia-based software package like SuperCard is that it provides many of the features needed for interactive training

systems, yet leaves the application of these features up to the imagination and ingenuity of the training system designer/developer. The ability to create, position, color, re-size, and add functionality to windows, cards, buttons, fields, and objects without programming, and then to further enhance their functions with scripts, gives the designer/developer an ideal tool. However, the scripting language, due to its interpretive nature, runs very slowly, particularly on anything less than the top-of-the-line Macintosh hardware (fx model).

The true advantages and disadvantages of PACEXTRA as a training system will not be known until it is tested and employed in the field, which is beyond the scope of this project. However, experience in applying the PACEXTRA exercise authoring system has shown it to be very efficient and easy to use.

Potential Application

PACEXTRA itself, because it was designed specifically to train only the CAS Exec at PACAF, has no other potential direct application. However, the approach to event-driven exercise-based training which it exemplifies has application to nearly any event-related job. For example, it could be used to train store clerks to handle various customer situations. At the other end of the spectrum, it could be used to give space crews pseudoexperience with mission events which require them to make decisions and take actions. To convert PACEXTRA to train another job would primarily involve creating the proper graphic environment and the on-the-job tools. The underlying PACEXTRA system has generic application potential.

The real potential of the type of training system PACEXTRA represents is to teach both procedural- or rule-based decision-making and knowledge-based decision-making, particularly because it provides so much of the complex context of a decision environment. This is in contrast to procedural trainers which simply list "rules" or procedures with little sense of the "knowledge" that is gained by experience in the decision context. This is the force behind expensive "virtual world" devices. The advantages of the PACEXTRA approach is its low cost, availability, focus on coordination of activities (i.e., teamwork), and speed of exercise authoring. There is little evidence to suggest the true need for the "glamor" of high-tech reality. What is needed is the work-inspiring nature of an interactive environment. PACEXTRA appears to provide this, at a low cost and with minimal effort on the part of scenario authors. Its potential seems to be significant.

Recommended Follow-On

As described elsewhere in this report, the event-driven exercise format of PACEXTRA has innumerable other potential applications, and the authoring system which it incorporates makes it relatively easy for trainers to create and modify training exercises. A natural follow-on, therefore, would be to modify the system (primarily the authoring system) to focus on another job and its environment so exercises could be created to train that other job.

However, an even more useful follow-on would be to experiment with developing a higher-level "authoring" process which would permit training system developers to create their own exercise authoring system for their unique jobs. This higher-level authoring process could then permit the exercise-based training exemplified in PACEXTRA to be applied to training any other job, without going through the time and expense of building the supporting tailored authoring system through programming. Rather, the trainers could develop their tailored authoring system themselves, through an interactive process similar to that of other interactive Macintosh applications. The result could add another dimension to the media and methods available in technical and operational training throughout the Air Force and elsewhere. (Note: With the advent of Windows 3.0 and object-oriented hypermedia applications such as Toolbook, this approach now appears practical on the IBM PC and compatible family of computers as well.)